Autecology and Synecology of Western Larch

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Abstract—Western larch occupies a limited geographic range in the Northwestern United States and Western Canada and exhibits moderate ecological amplitude within this range. Larch's shade-intolerance relegates it to an exclusively seral successional role. Great longevity and exceptional fire resistance account for its occurrence in late-successional stands. Western larch will likely decrease in abundance compared to historical levels. Effective wildfire suppression and decreased use of clearcut and seed-tree regeneration methods will likely put larch at a competitive disadvantage compared to its associates.

Western larch (*Larix occidentalis*) is a distinctive western conifer due to its brilliant autumn color, rapid growth, and deciduous habit. Larch's properties make it a preferred species for dimension lumber and utility poles, and a favorite among western woodcutters for firewood. This species has also picked up a myriad of common names over the years, including hackmatack, larch, western larch, great western larch, Montana larch, Oregon larch, red American larch, tamarack, western tamarack, and British Columbia tamarack (Green 1933).

TAXONOMY

Western larch is genetically distinct from all other species occurring within its range, with one exception. Western larch occasionally hybridizes with subalpine larch (*Larix lyallii*) where the elevational ranges of the two species overlap (Carlson and others 1990). Hybrid vigor resulting from crossing other larch species has already been exploited. Carlson and others (1990) hypothesize that a *L. occidentalis* x *L. lyallii* hybrid retaining the rapid growth characteristic of the former along with the cold-hardiness of the latter would have considerable management potential.

HABITAT

Distribution

Western larch occupies a limited geographic range in four States (Montana, Idaho, Oregon, and Washington) and two Provinces (British Columbia and Alberta). This species is found in a zone roughly east of the Cascades in Washington, north of the Salmon River in Idaho, west of the Continental Divide in Montana, and south of the 52nd parallel in interior British Columbia and extreme western Alberta. However, Eliot (1938) reported western larch on the west side of the Cascades south of Mount Hood in Oregon; Fiedler (1968) observed larch about 10 miles east of the Continental Divide in northwest Montana; and Lloyd and others (1992) reported an isolated stand of larch approximately 60 miles north and west of its previously documented northern limits in British Columbia.

Western larch is limited by drought at the lower end of its elevational range, and by cold temperatures at higher elevations. In the United States, western larch ranges as low as 2,000 ft in northern Idaho and extreme northwestern Montana, and as high as 6,500 ft (Habeck 1967) to 7,000 ft (Sudworth 1918; Larsen 1930) in western-central Montana and central Idaho. Larch occurs almost exclusively on north and east aspects as it approaches the southern (dry) end of its range; however, it can occur on all aspects on moister sites and in the northern portion of its range.

Climate

Western larch occurs in moderate environments relative to the breadth of climatic conditions within its geographic range. Table 1 depicts the range of climatic parameters associated with the forest habitat type series (United States) and biogeoclimatic units (Canada) within which larch occurs.

Soils

Western larch is typically found on deep, well-drained soils that have developed from glacial till or colluvium parent materials. These soils commonly have volcanic ash incorporated into the surface horizon. The greatest deposition of volcanic ash typically occurs on north to east aspects (Nimlos and Zuuring 1982)—aspects favored by western larch. In the United States, larch most commonly occurs on soils classified within the Alfisol or Inceptisol (and less frequently, Spodosol) soil orders. Embry (1960) found that growth performance of western larch in Montana was significantly related to effective soil depth. However, Pearcy (1965) could find no physiographic or soil factors to predict larch site index in the Swan Valley of western Montana. Spitzner and Stark (1982) investigated differential larch growth rates on andic soils overlaying glacial tills in northwestern Montana. Larch grew better on rapidly drained sites than on otherwise similar sites with slow subsoil percolation. Spitzner and Stark (1982) hypothesize that nutrient deficiencies resulting from a restricted rooting zone on the poorly drained sites limited growth more than moisture

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Table 1—Climatic profile of forest habitat type series (United States) and biogeoclimatic zones (Canada) where western larch occurs.

Habitat type series Biogeoclimatic zone		DF IDF	GF MS	WC/WH ICH	ES/AF ESSF
Mean Annual Precip.	(in)	17-50			
	(cm)	37-57	50-68	57-113	70-85
Mean Growing Season Prec.	(in)	6			
	(cm)	18-27	20-29	21-37	20-32
Mean Annual Snowfall	(in)	103			
	(cm)	120-350	193-450	130-560	200-620
Mean Annual Temperature	(F)	45			
	(C)	4.0-7.5	2.5-4.0	2.5-7.8	1.0-2.5
Frost–free Conditions	(season)	60-160			
	(days/yr)	40-140	35-80	50-170	40-70

Adapted from Schmidt and others (1976) and Goetz (1983)

ress on the well drained sites. General characteristics f soils supporting western larch are shown in table 2.

YNECOLOGY

cological Amplitude

Western larch exhibits moderate ecological amplitude ithin its restricted geographical range; it does not occur n very warm or dry sites, nor on cold or wet ones.

Western larch occurs as a seral species in 24 of the 64 rest habitat types in Montana (Pfister and others 1977), n 30 of the 41 habitat types in northern Idaho (Cooper nd others 1987), and in 11 of 21 habitat types in eastern Washington (Daubenmire and Daubenmire 1968) (table 3).

ssociated Tree Species

Western larch is found in four major forest types in the United States and Canada—Douglas-fir, montane pruce/grand fir, interior cedar/hemlock, and Engelmann pruce/subalpine fir. Primary associates of western larch n the Douglas-fir type are Douglas-fir (*Pseudotsuga menziesii* var. *glauca*), ponderosa pine (*Pinus ponderosa*), and lodgepole pine (*Pinus contorta*). Grand fir (*Abies grandis*), Douglas-fir, Engelmann spruce (*Picea engelmannii*), subalpine fir (*Abies lasiocarpa*), and lodgepole pine commonly co-occur with larch in the grand fir type in the United States; ponderosa pine and paper birch (*Betula papyrifera*) are occasional co-occurrents. Douglas-fir and white spruce (*Picea glauca*) are primary associates of western larch in the montane spruce type in Canada. Major associates of larch in the cedar/hemlock type are western redcedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), Douglas-fir, Engelmann spruce, subalpine fir, and grand fir. Minor associates in this type include lodgepole pine, western white pine (*Pinus monticola*), and paper birch. Engelmann spruce, subalpine fir, Douglas-fir, and lodgepole pine are common companions of larch in the Engelmann spruce/subalpine fir type, while western white pine and whitebark pine (*Pinus albicaulis*) are occasional associates.

Table 2—Primary characteristics of soils supporting western larch in the United States and Canada.

	United States	Canada
Parent Material	Glacial tills, colluvium Tertiary alluviums Volcanic intrusives	Morainal and colluvial Glacial fluvial (minor)
Development	Inceptisols Alfisols (Spodosols)	Dystric Brunisols Humo-Ferric Podzols Brunisolic Gray Luvisol
Texture	Gravelly loam to silt loam surface soils; silt loam to clay subsoils	Fine clay to coarse sandy
pH	4.8-6.1	4.5-5.8 Calcareous (7.5-7.8)
Humus depths	Mean: 1-2 in Range: 1-8 in	Mean: 4-5 cm Range: 1-25 cm

Successional Status

Western larch is the most shade intolerant species within its range, relegating it to an exclusively seral successional role. Larch is an aggressive pioneer in the historically fire-dominated ecosystems within which it occurs. However, larch's longevity—300 to 500 years common, occasionally 700+ years (Franklin and Dyrness 1973), maximum 900+ years (USDA Forest Service 1965)—accounts for its occurrence as relicts in late-successional stands. Western larch traits of low shade tolerance and rapid early height growth are characteristic of early successional species. However, some other attributes of larch, such as relatively advanced age to first seed production (~25 years) and great longevity (700+ years), are more representative of late-successional species based on classical r-K selection theory (Turner 1985). The capability of mature larch to occasionally survive stand replacement wildfires is due to thick bark and the considerable height of the crown base above the ground. Furthermore, defoliation by fire is less traumatic for larch than for other conifers, since it replaces its needles annually anyway (Fischer and Bradley 1987). These attributes, coupled with low seed weight (137,000 seeds/lb; USDA Forest Service 1974), give larch a different strategy than lodgepole pine for regenerating extensive burned areas, but one that is nearly as effective.

Table 3—Occurrence of western larch relative to forest habitat type series in Montana, Idaho, and eastern Washington.

Classification (geographic area and author)	Forest habitat type series	Number of habitat types within series	Number of habitat types with WL
Montana (Pfister and others 1977)	Limber Pine	3	0
	Ponderosa Pine	5	0
	Douglas-fir	14	7
	Engelmann Spruce	8	2
	Grand Fir	3	3
	Western Redcedar	2	2
	Western Hemlock	1	1
	Subalpine Fir	23	9
	Lodgepole Pine	5	0
N. Idaho (Cooper and others 1987)	Ponderosa Pine	4	0
	Douglas-fir	7	4
	Grand Fir	7	7
	Western Redcedar	6	6
	Western Hemlock	4	4
	Mountain Hemlock	4	4
	Subalpine Fir	6	5
	Lodgepole Pine	3	0
E. Washington (Daubenmire and Daubenmire 1968)	Ponderosa Pine	6	0
	Douglas-fir	3	3
	Grand Fir	1	1
	Western Redcedar	3	2
	Western Hemlock	1	1
	Mountain Hemlock	2	2
	Subalpine Fir	4	2
	Whitebark Pine–SAF	1	0

AUTECOLOGY

Silvical Characteristics

Autecological characteristics are important in that they define the ways in which a given species is unique. They also provide insights into a species regeneration habit, successional behavior, management potential, and distributional limitations. Western larch is a rather modal species in terms of most silvical characteristics, with two notable exceptions: it is extremely shade intolerant, and it is highly resistant to fire. Western larch's silvical attributes are listed in relation to its associates in table 4.

Regeneration

Western larch seeds germinate from late April to early June, usually about a week or two earlier than associated species (Shearer 1967). Death of first-year seedlings early in the season is mainly due to biotic factors such as fungi, birds, and rodents, whereas drought is the primary cause of seedling mortality after about mid-July (Schmidt and Shearer 1990).

Western larch is more dependent on a prepared seedbed to regenerate than any of its associates, including lodgepole pine (Fiedler 1990). Successful regeneration of western larch virtually requires mineral soil or burned seedbeds (Shearer 1980; Schmidt and Shearer 1990). The probability of larch stocking after clearcutting has also been found to vary inversely with elevation and percent grass/sedge cover (Fiedler 1990).

Height Growth and Site Index

Western larch exhibits rapid height growth. Fiedler (1990) found larch to outgrow all of its common associates to age 12, with the exception of lodgepole pine (identical). Schmidt and others (1976) reported that western larch and lodgepole pine heights are also similar at age 50, but that larch is taller at age 100 than any other conifer in the Northern Rockies. However, Deitschman and Green (1965) and Steele and Cooper (1986) report that western white pine is taller than larch at age 100 on productive sites—site index >60 (18.3 m), base age 50—in northern Idaho. Mean maximum height of western larch varies from a low of 96 ft, ±10 ft (29.3 m, ±3.0 m) on the *A. lasiocarpa/X. tenax* h.t. to a high of 149 ft, ±21 ft (45.4 m ±6.4 m) on the *T. plicata/C. uniflora* h.t. (Pfister and others 1977).

In the United States, western larch site index (base age 50) varies from about 50 ft (15.2 m) in the relatively cold, dry habitat types within the subalpine fir series, to about 80 ft (24.4 m) in the warm, moist western redcedar/western hemlock series (Pfister and others 1977; Cooper and others 1987). Mean site index for this species is shown by habitat type series and biogeoclimatic zone in table 5.

Productivity

Western larch, because of its deciduous habit, would appear to be at a growth disadvantage to sympatric evergreen conifers. Furthermore, for trees of a given diameter, larch has much lower foliage biomass than its associates (Brown 1978). However, both larch and its associates have similar aboveground production rates. Gower and Richards (1990) attribute larch's low-carbon-cost, well-illuminated, nitrogen-efficient canopy for carbon allocation rates similar to evergreen conifers. Total cubic volume production of western larch at age 100 varies from about 2,950 ft^3/acre (206 m^3/ha) on low quality sites, to 6,000 ft^3/acre (420 m^3/ha) on medium sites, to 9,600 ft^3/acre (672 m^3/ha) on high quality sites (Schmidt and others 1976).

Pests

While western larch is susceptible to numerous pests, few are lethal to trees of pole size or larger. Primary insect pests include larch casebearer (*Coleophora laricella*), larch sawfly

Table 4—Relative silvical characteristics of western larch and its common coniferous associates.

	Low ——> Moderate ——> High
Shade tolerance	**WL** LP PP WP DF ES GF AF WC WH
Frost tolerance	WH WC GF PP **WL** DF WP AF ES LP
Drought tolerance	WH WC AF ES WP GF **WL** LP DF PP
Fire resistance	WH AF ES WC LP GF WP DF PP **WL**
Excess water tolerance	PP DF **WL** GF WP AF WH ES WC LP

AF Subalpine fir
DF Douglas-fir
ES Engelmann spruce
GF Grand fir
LP Lodgepole pine
PP Ponderosa pine
WC Western redcedar
WH Western hemlock
WL Western larch
WP Western white pine

Table 5—Mean 50-year site index for western larch in the Northern Rocky Mountains (by forest habitat type series)[1] and British Columbia (by biogeoclimatic zone).

	H.T. series	DF	GF	WC/WH	ES/AF
50-year S.I. (ft)	mean	59	67	71	61
(Northern Rockies)	range	55-74	62-72	62-80	51-67
	BGC zone	**IDF**	**MS**	**ICH**	**ESSF**
50-year S.I. (m)	mean	17	20	23	17
(British Columbia)	range	13-19	16-22	18-26	16-21

[1]Adapted from Pfister and others 1977, and Cooper and others 1987.

(*Pristiphora erichsonii*), and western spruce budworm (*Choristoneura occidentalis*). Casebearer larvae can completely defoliate larch trees in the spring by mining the needles. Continued defoliation reduces radial growth significantly and can cause mortality (Tunnock and others 1969). The impact of casebearer appears to be inversely related to stand density (Denton 1979). The larch sawfly is a periodically significant defoliator of larch. This insect leaves its signature by biting chunks out of needles rather than mining them, but seldom causes mortality (Drooz 1956). The western spruce budworm is particularly damaging to sapling-sized trees. Budworm larvae typically sever the terminal and current-year laterals of young larch (Fellin and Schmidt 1967), damage that reduces height growth and affects form (Schmidt and Fellin 1973). Spruce budworm larvae have also been documented doing damage to larch cones and seeds (Fellin and Shearer 1968). While Douglas-fir bark beetle (*Dendroctonus pseudotsugae*) will attack western larch (Furniss and others 1981), successful brood production in standing live trees has never been documented (Reed and others 1986). Larch's apparent resistance to the Douglas-fir beetle is attributed to its high concentration of 3-carene, a xylem monoterpene that has a significant negative correlation with beetle attack rate.

Major diseases infecting larch include dwarf mistletoe, needle blight, needle cast, and root/stem rots. Trees parasitized by larch dwarf mistletoe (*Arceuthobium laricis*) commonly develop witches brooms, burls, and spike tops. Mistletoe infection reduces growth and increases vulnerability to other damaging agents, but only occasionally causes death (Kimmey and Graham 1960; Pierce 1960). Initial visual symptoms of needle blight (*Hypodermella laricis*) and needle cast (*Meria laricis*) are similar—red needles (Leaphart and Denton 1961). However, needles infected with blight are retained on the tree for a year or more, whereas needles infected with needle cast are typically shed within weeks after infection (Hagle and others 1987). Larch is also susceptible to red ring rot (*Phellinus pini*), schweinitzii root/butt rot (*Phaeolus schweinitzii*), and quinine fungus (*Fomitopsis officinalis*).

DISCUSSION

Bad news—The range of western larch, as with other western tree species, is determined by drought at low elevations and by cold temperatures at high elevations. Within its range, successful perpetuation of this species requires full or nearly full sunlight and mineral soil or burned seedbeds. Historically, these conditions were provided by wildfires. More recently, managers have created favorable conditions for larch regeneration using either clearcut or seed-tree regeneration methods, followed by dozer scarification or broadcast burning. However, changing management direction, especially on publicly owned lands, points to decreased use of clearcut and seed-tree methods, and less severe and complete site preparation. The resulting environmental and seedbed conditions will likely put larch at a competitive disadvantage compared to its associates.

Good news—Two developments related to the geographic distribution of western larch offer promise for expanding the traditionally recognized natural range of this species. The first development is the discovery of a disjunct stand of western larch approximately 60 miles (100 km) north of the previously recognized northern limit of this species in British Columbia. The location, size, age, and density attributes of this isolated population have been documented by Lloyd and others (1992). The apparent vigor and ability of this population to reproduce suggests that management efforts to extend larch northward to this latitude from its existing limits may well be successful.

A second development is the apparently successful planting of western larch at several locations north and west of its traditionally recognized range in British Columbia. Some extended plantings have survived and grown for up to 20 years. The current northern limit of western larch is believed to be determined by cold-temperature disruption of the regeneration process. This limiting factor can be circumvented to some degree using artificial regeneration.

Carlson (1994) has outplanted western larch, subalpine larch, and *L. occidentalis* x *L. lyallii* hybrids at four locations outside their natural ranges in Montana. Early results are promising, particularly for the hybrids. However, survival and adequate growth to mature size will be required before such efforts can be deemed a success.

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